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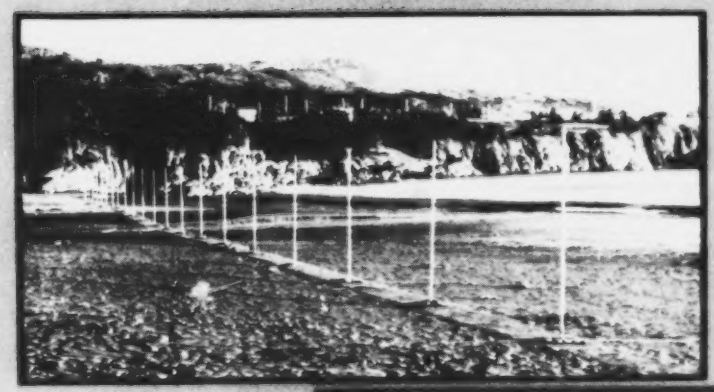
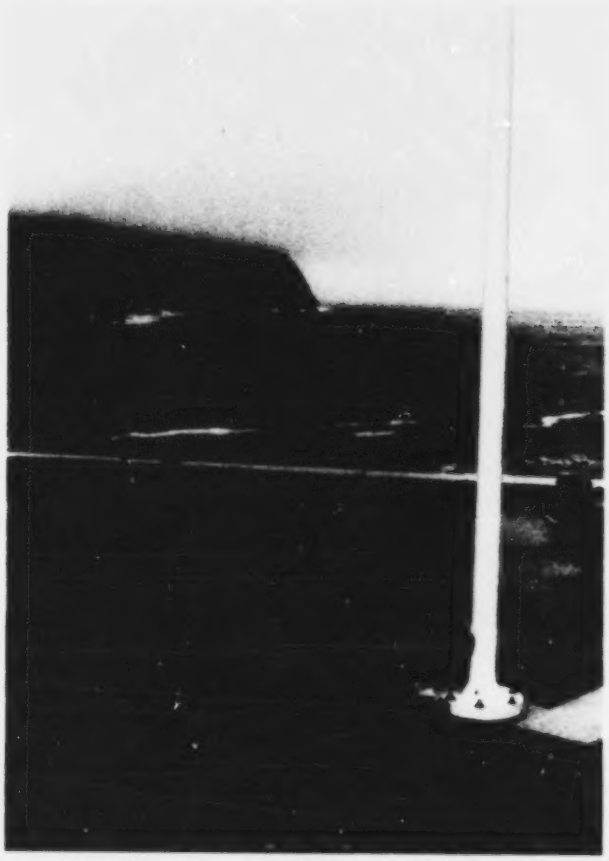
C-CORE

Report of Activities

1986 - 1987



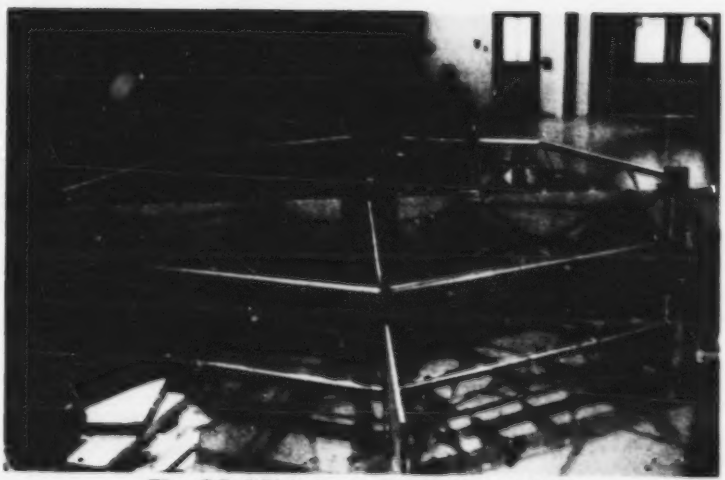


Installing the 6.8 MHz conversion of C-CORE's CODAR at the Marine Sciences Reseach Laboratory, Logy Bay

C-CORE researcher removing ice samples for laboratory analysis, Resolute, N.W.T.

Cover: L-R

- Antenna configuration for ice detection using Ground Wave radar
- Testing site, Resolute, N.W.T.
- CO-ASI field trials — Conception Bay, Newfoundland



The CO-ASI being constructed at IMD

91-00984/

Report of the Director and Board of Governors 1986-1987

As we predicted two years ago, 1986 and 1987 have been very challenging years for C-CORE. The collapse of world oil prices early in 1986, coupled with extensive government cutbacks had a severe impact on research funding in Canada, particularly on research related to petroleum resource development. In spite of this economic climate, the Centre managed to retain the confidence and energetic support of its Associates. Major research funding was actively and successfully pursued and the Centre's Five Year Research Plan was revised to be even more responsive to the needs of industry and government.

C-CORE implemented a number of measures to make certain that it would remain sound and viable and that it would retain a critical mass of expertise. Within the three major areas of research, **Ice Engineering**, **Remote Sensing** and **Seabed Geotechnics**, the greatest emphasis was placed on Ground Wave radar research, the Geophysical/Geotechnical program and Ice Mechanics. During the year, research activities and expenditures were monitored and carefully controlled. The Centre appointed senior staff who in turn attracted major sources of research funding. By the end of the year, C-CORE had negotiated over a million dollars worth of contract funding, a record amount for the Centre in one year.

Strong technical links had already been developed with national and international groups. Co-operative research projects, which allowed participants to achieve their objectives at significantly lower cost, started to play an increasingly important part in the Centre's research activities, and field programs were undertaken off the east coast of Canada, the Beaufort Sea and in the Arctic. The support from our Associates, both in financial terms and in support-in-kind, gave C-CORE confidence to continue with the research work. The technical direction provided by the Associates for the Centre's programs ensures that C-CORE's research remains relevant to the changing needs of the offshore sector.

In spite of the financial pressures faced by the staff during the year and the increased emphasis on finding new sources of funding to support the work, productivity increased and more reports of C-CORE's research were published in refereed publications. These publications have also had a positive impact on funding received from the Natural Sciences and Engineering Research Council (NSERC). Support from NSERC has grown over the last two years; awards have been made in Operating, Equipment, Strategic and Infrastructure Grants. The Centre is also well placed to take advantage of the University/Industry programs for co-operative research and development. Two grants have been awarded to C-CORE, and the Centre played a significant role in the award of another Co-op R&D Grant.

The announcement in March 1987 that C-CORE was being awarded $5 million from the Offshore Development Fund over the next five years put the Centre in a unique position to lever funds from other sources. To receive the Offshore Development Funds, the Centre must obtain $11.25 million from other sources. Each year, the Centre must achieve a financial target to draw on the monies in the fund allocated for that year. In the first year of the contract, the Centre achieved its target in the first six months. C-CORE would like to thank all those involved in this award. Their confidence in the Centre and its research activities is very encouraging.

The Centre had implemented a Five Year Research Plan in 1985 which had to be cut back in 1986; however, the encouraging growth in support for C-CORE's research activities necessitated a major review of the plan. A research planning workshop was held, lead by Ken Croasdale of Esso Resources Canada Limited and attended by representatives of the Associates and other experts from universities, governments and industries. The workshop used an operational scenario approach to identify technical issues and opportunities. Subsequently, research activities appropriate to C-CORE's capabilities were identified; the three major research thrusts were retained and within each thrust, three major program areas were identified.

Ice Engineering:	Mechanical Properties Ice Dynamics Ice/Structure Interaction
Remote Sensing:	Fundamental Research Target Detection Environmental Measurements
Seabed Geotechnics:	Marine Geophysics Marine Geology Marine Geotechnics

The revised five year research plan was endorsed by the Board of Governors of C-CORE at its fall meeting.

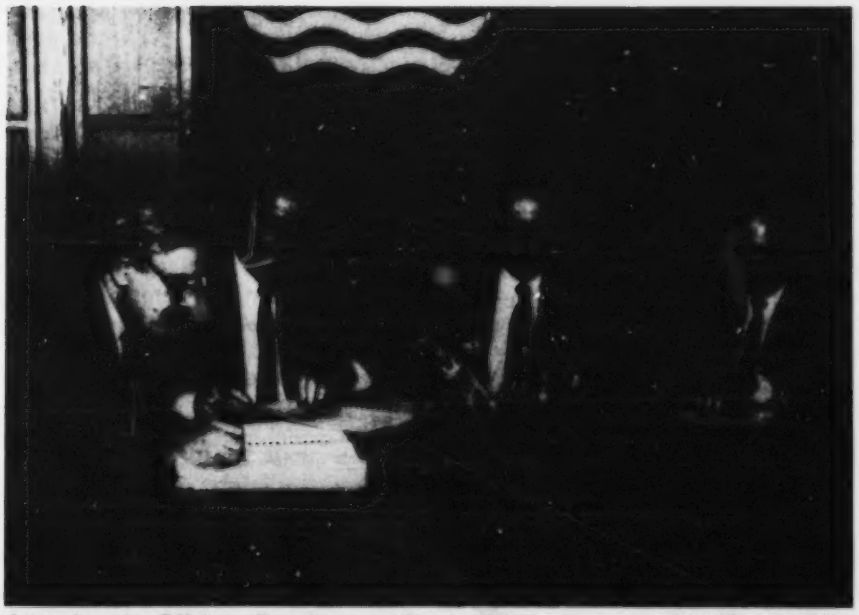
continued page 2

The success and continued viability of C-CORE is due to the tremendous efforts of the members of its Board of Governors and its staff. The direction and guidance of the Board of Governors have helped C-CORE establish strong research programs that have gained international recognition. The dedication and commitment of the staff, through the times of restraint and now in a time of growth, are the bases of C-CORE's success. The students of Memorial University and other institutions in St. John's are also closely involved in our research work. Their work at C-CORE gives these students excellent opportunities to be involved in field programs and work with industry and government groups. Inter-disciplinary relationships are also established with the scientists and engineers from other organizations who often work at C-CORE on specific projects. These relationships are beneficial to all parties and over the next year, we project a rapid growth in this type of collaboration between research groups in Canada.

The growth of expertise in marine sciences and ocean technology in St. John's reflects the co-operative research activities of the Newfoundland community. The strong working relationships C-CORE has developed with industry, government and university groups, have contributed significantly to this development. The Centre is uniquely placed to initiate and participate in co-operative programs. This next year promises to be active and exciting.

J.I. Clark
Director of C-CORE

G.C. Eaton
Chairman of the Board of Governors



Attending the Offshore Development Fund signing ceremony: (R-L) Mr. Joe Price, Member of Parliament for Burin-St. George's; Dr. Ian Rusted, Memorial's Vice-President, Health Sciences and Professional Schools; Hon. Hal Barrett, Provincial Minister of Development and Tourism; and Dr. Jack Clark, Director of C-CORE. (photo: J. Bourne, MUN)

FIVE YEAR RESEARCH PLAN
1987 - 1991

Five Year Research Plan
1987 - 1991

The research objectives defined in C-CORE's five year research plan address problems identified as being important to the exploration and development of Canada's offshore resources and topics related to improved cost effectiveness or safety. C-CORE continues to look ahead for a five year period to anticipate technical problems, to propose new solutions and to maintain its position at the leading edge of cold ocean technology.

After extensive discussions with industry and government C-CORE has revised and updated its original five year plan of 1985 - 1990. The Board of Governors of C-CORE approved the revised plan at the October 1987 meeting.

Ice Engineering

C-CORE's ice research plan has been revised to increase the emphasis on the engineering aspects of ice.

Mechanical Properties

Current research into the basic mechanical properties of ice will continue to ensure that baseline data on ice properties are available for further engineering studies. This fundamental research program will include theoretical, experimental and field studies to investigate the mechanisms and modes of ice failure. Ice indentation tests will provide data which can be used in the verification and refinement of proposed theories and numerical models.

Working closely with operators in the Beaufort Sea, analyses will be undertaken on sprayed ice properties as they relate to offshore platform construction. The primary objective of these studies is to determine the basic engineering properties of sprayed ice as a "building material".

New research initiatives will consider problems relating to ice adhesion and icing in the offshore. The program will be developed in close collaboration with other groups already working in this field of research. C-CORE's program will specifically address icing problems faced by industries operating in eastern Canada.

Ice Dynamics

Work will continue on the assessment of hazards to offshore structures posed by wave-driven small ice masses. Now that size/seastate/velocity correlations are fairly well established, the probability of impact will be determined and risk analyses developed to estimate design loads.

Investigations will also continue on the behaviour of icebergs when they are scouring and pitting the seabed. The rigid body behaviour of bergs scouring up and down slope, and the influence of pack ice driving loads, will be studied experimentally and theoretically.

The technology developed for the study of ice motion will be applied to the development of offshore evacuation systems for the north Atlantic.

Research work will be undertaken to enhance current ice management techniques. A program will be initiated for the design, development and demonstration of a new single point attachment system for towing icebergs. Extensions of this technology will be applied to iceberg fragmentation.

Ice/Structure Interaction

The interaction of ice with artificial structures is an important consideration in the design criteria for east coast or Arctic offshore structures: floating or bottom founded, subsea or surface piercing. The overall objectives of the program are to use the data from the Centre's Ice Mechanics, Ice Dynamics and Geotechnical programs to investigate the interaction of sea ice and icebergs with offshore structures and to provide the engineering data for the structural design of offshore systems.

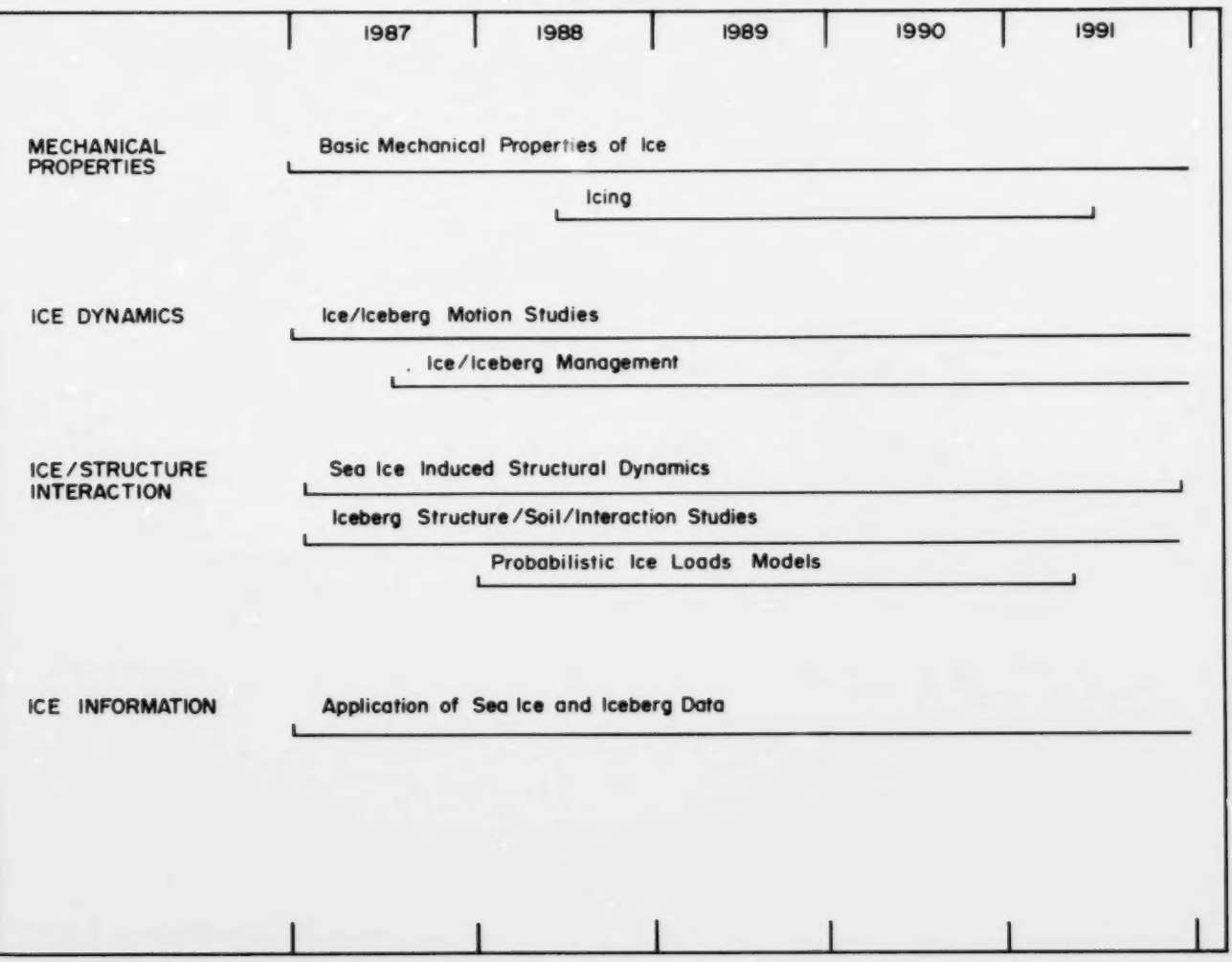
Programs for the Beaufort Sea will investigate the dynamic response of foundations under sea ice loads. Theoretical models using known statistical distribution of environmental conditions and numerical simulation will be used to establish the probability of various ice impact loads.

Experiments to determine pipeline response to iceberg scour will be conducted. Improved theoretical models which account for the material properties of ice and soil as well as the direction of the loading will be verified.

Ice/Offshore Information

New developments in computer systems will be applied to the acquisition and retrieval of ice and offshore information. The Canadian Sea Ice Information System will be evaluated in light of other available ice systems. Further developments will emphasize client needs and support the activities of the ice/structure programs.

ICE ENGINEERING



Remote Sensing

The transfer of the Ground Wave radar technology to the private sector for commercial applications will be a major activity for the group over the next five years.

Basic Research

The Remote Sensing Group is currently involved in fundamental research in electromagnetic propagation and scattering, and in signal processing and data analysis. These studies are the bases upon which the applied remote sensing programs are being developed.

Electromagnetic (EM) Propagation and Scatter

The development of new techniques for the solution of electromagnetic problems will lead to a greater understanding of the fundamental propagation and scattering of EM waves and will enhance the use of EM for remote sensing. These techniques are now being applied successfully to solve a variety of problems including propagation and scatter for the ocean surface, and the prediction of iceberg radar cross section. They are also used to estimate scattering from metallic targets, such as vessels on the ocean surface. New techniques will be developed to predict the radar cross section from these metallic targets and be extended to targets that are above the ocean surface such as aircraft. Methods developed in these studies may be applied to projects which use other modes of radar propagation.

Further studies in ocean surface propagation and the effects of multiple scattering will be undertaken. This will enhance the ability of the Centre's target detection and environmental measurement programs to detect ice and ocean hazards. The feasibility of using EM to detect hazardous ice features in oceans where there is total ice coverage also will be studied.

Signal Processing/Data Analysis

A significant research effort in signal processing and data analysis is required to develop new algorithms to extract and enhance information on ice and ocean hazards in the EM signals. The research program will focus on ocean clutter reduction and enhancement, spectral estimation techniques and signal detection. The methods developed in this program for extracting information from the EM signals will have application in other engineering research areas which involve signal processing.

Ground Wave Radar

Target Detection

Ground Wave radar technology will be used to develop detection systems for ice, icebergs, vessels and low flying targets. Two types of systems will be developed: a long range shore based system and a shorter range rig or vessel system.

A Shore Based Ground Wave Radar System will be developed through a joint project arrangement with the private sector. The aim is to develop a multi-purpose radar system capable of monitoring vessel traffic, detecting and tracking icebergs/sea ice edges and performing ocean wave measurements with a range out to the Canadian territorial limit. C-CORE has developed engineering specifications for the prototype system with industry. The next phase will be to design and construct the prototype for Canadian east coast applications. This technology may then be applied to any ocean environment.

The Ice Hazard Detection Ground Wave Radar program will develop the Ground Wave radar technology for use on drilling rigs or vessels. The program will address problems encountered in the offshore environment: ocean clutter, platform motion and the need for compact rig based antenna systems. Extensive signal processing research is being carried out to develop algorithms to deal with these problems.

Environmental Measurements

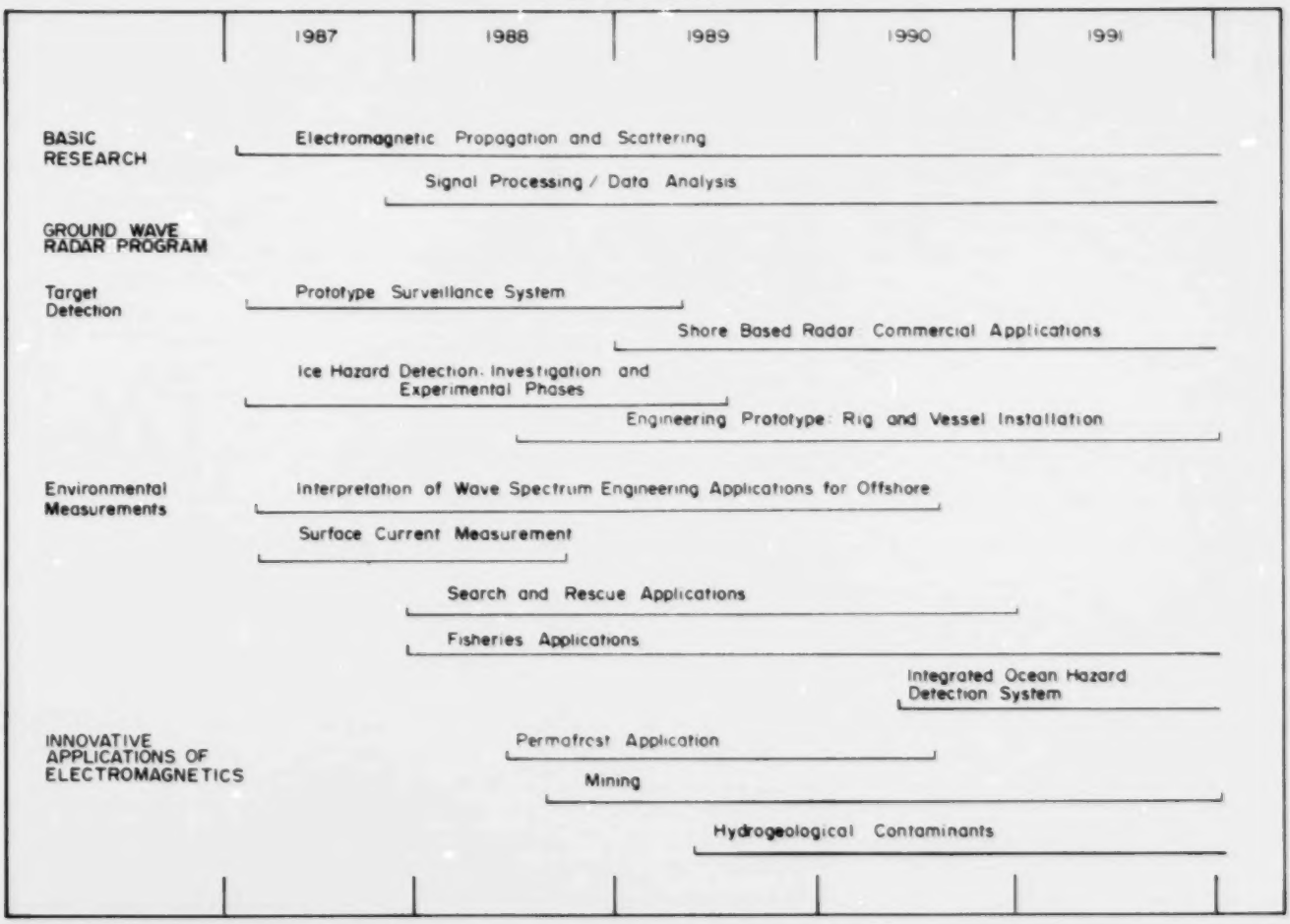
The Interpretation of Wave Spectra for Ground Wave radar technology will be applied to the estimation of the ocean wave spectrum. Basic analytical modelling of the ocean surface return, interpretation of measured data using the models and signal processing and data analysis techniques will be undertaken. This program is being carried out co-operatively with researchers from the Bedford Institute of Oceanography who will provide information on ocean surface modelling and identify user requirements in the oceanographic community. This program will develop specifications for a Ground Wave radar system for ocean wave observations to be incorporated into shore based or rig and vessel based radar systems.

Surface Current Measurement techniques using Ground Wave radars are at a relatively mature state. Systems are available for current survey measurements (short range), and current interpretation algorithms may be utilized with the long range shore based prototype system when it is available. The Centre is presently exploring commercial applications for the techniques, including search and rescue applications, to be carried out in co-operation with the private sector.

Innovative Applications of Electromagnetics

The analytical techniques which evolve from the Ground Wave radar program will be applied to problems in the Geo-electromagnetics field. The program will examine the potential of using electromagnetics for geophysical prospecting and probing geotechnical properties of the sea bed and the onshore environment.

REMOTE SENSING



Seabed Geotechnics

The original Seabed five-year plan was modified to reflect the shift in emphasis from qualitative seabed reconnaissance studies to an integrated tri-disciplinary research approach.

Marine Geophysics

Geophysical/Geotechnical Sediment Property Correlation

Relationships will be established between acoustic properties (velocity and attenuation) and geotechnical properties (density, porosity, shear modulus, and damping) of selected sediments in support of the Acoustic Sub-seabed Interrogator (ASI) and its associated developments. This represents an ongoing investigation of soil properties. Compression and shear wave propagation in silica sands will be studied as void ratio is varied. Studies of dynamic behaviour of the same soils (as strain amplitude is varied) will be conducted in collaboration with the National Research Council Canada using cyclic simple shear, cyclic triaxial and resonant column equipment. These results will be compared with theoretically calculated values. Future work will entail the investigation of compressional and shear wave data while varying effective stress and will provide information on variation of geophysical property gradients with depth. Potential applications for these results include improved modelling of acoustic boulder detection techniques. In addition, the application of ASI concepts to monitor seabed behaviour under dynamic loading and environmental perturbations will be investigated.

Innovations in Acoustic Technology Offshore Conventional Optimization Acoustic Sub-seabed Interrogator (CO-ASI) Design and Fabrication

A CO-ASI, based on the ASI concept, will be designed and fabricated. It will consist of advanced design, multi-tip sparker sources and sound intensity directional receivers mounted on a 5m diameter platform. The CO-ASI will be engineered to perform layer-by-layer interrogation of a complex seabed to a depth of 100m. High-resolution acoustic velocity and attenuation information will be acquired and related to physical and geotechnical soil properties derived from the C-CORE laboratory study.

Developments of the marine geophysics program may be applied to any marine environment for cost effective seabed surveys. They could also be applied in fresh water.

Sound Intensity Techniques to Study Fatigue in Offshore Structures

The program will develop a technique, using acoustic intensity scanning, for the remotely sensed non-destructive assessment of fatigue and crack growth in offshore structures. The innovative use of acoustic energy is a natural outgrowth of the geophysics program. The investigation will be based on fundamental acoustic principles for mapping energy flow in structures using sound intensity and digital filtering. Initial efforts will be made to calibrate the method and establish the confidence limits.

Marine Geotechnics

Ice/Seabed Interaction

The interaction of icebergs, sea ice, ice islands and pressure ridge keels with the seabed soil will be observed, defined, interpreted and modelled. The mechanics of ice/seabed interaction based on field studies of onshore examples, examination of modern scours offshore, and physical and theoretical modelling will be investigated. Studies of modern scours will employ the CO-ASI and state-of-the-art remotely operated vehicles. A co-operative program will be established between C-CORE and the Norwegian oil/gas industry to study geotechnical aspects of ice/seabed interaction.

Wave/Seabed/Structure Interaction

The program will assess and monitor the foundation behaviour of a model seabed-founded structure during intense wave loading. Pore pressures in the seabed will be measured by traditional and acoustic methods. The model currently being used in the study is a Molikpaq-type structure founded on silty clay seabed material. Pore pressures induced in the model seabed are monitored using piezostones as the structure is loaded by waves of varying heights and frequencies. The application of acoustic monitoring will be investigated in this project.

The results of these programs can be applied to developments in ice-infested or turbulent seas, in particular those of the Canadian east coast and of the Beaufort Sea.

Marine Geology

Shelf Sediment Studies

The compilation and evaluation of the Newfoundland and Labrador Hydro database on the Strait of Belle Isle to assess geological and engineering implications will be a significant program for the next two years. This database encompasses 20 years of investigations in a geologically complex area. Compilation and integration of this database with existing geological work will provide considerable insight into the structural and Quaternary history of the Strait. Geotechnical data on material quality and strength as well as seabed morphology will permit impact assessment of the geology on future developments.

Offshore Mineral Resource Evaluation

This program will provide a fundamental understanding and first order assessment of the marine mineral potential of the Canadian continental shelf and develop innovative technological methods of exploring for marine minerals.

The acoustic and conductive properties of placer minerals and their associated facies will be modelled theoretically and experimentally in support of the development of an *in situ* geophysical probe and a geophysical expert system. Selected field sites offshore British Columbia and Newfoundland are presently under investigation with respect to a genetic characterization of placer deposits and the calibration of geophysical models.

The marine geology programs are currently directed to Canada's east and west coasts but they have potential application for other offshore and onshore sites.

New Ventures

Bio-acoustics, Non-linear Acoustics, Robotics and Intelligent Systems

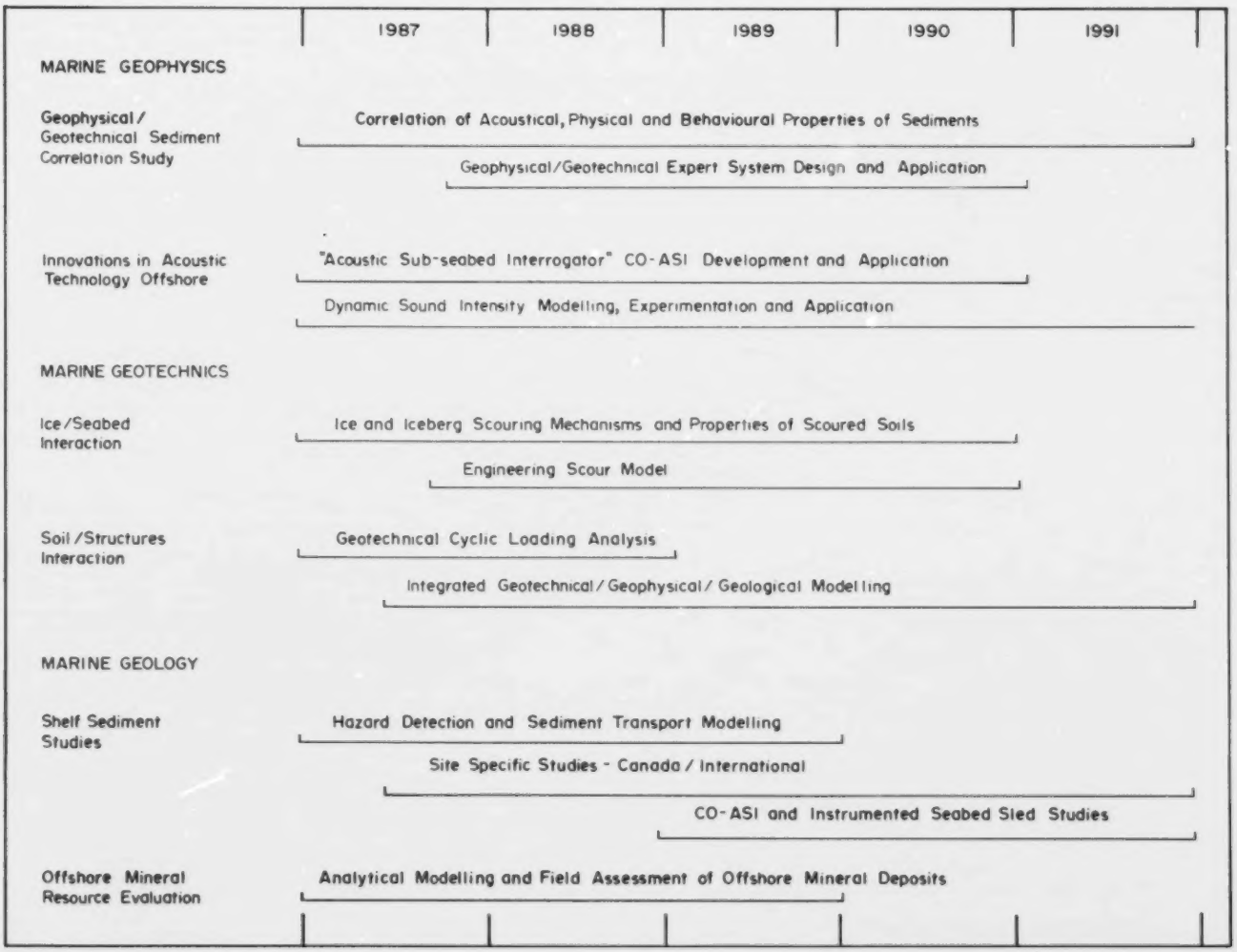
The program will be a multi-tasked set of projects drawing on many disciplines and technologies.

The bio-acoustic program will be a new venture in fisheries and aquaculture technology and will use methods developed in the geophysics program, for quality control of fish.

Non-linear acoustics will be applied to advanced underwater communication.

Studies in robotic, and artificial intelligence will be used to design specialized seabed monitoring probes, in particular a Robotic ASI for the private sector.

SEABED GEOTECHNICS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MARINE GEOPHYSICS
Geophysical / Geotechnical Sediment Correlation Study
Correlation of Acoustical, Physical and Behavioural Properties of Sediments
Geophysical/Geotechnical Expert System Design and Application
Innovations in Acoustic Technology Offshore
"Acoustic Sub-seabed Interrogator" CO-ASI Development and Application
Dynamic Sound Intensity Modelling, Experimentation and Application
MARINE GEOTECHNICS
Ice/Seabed Interaction
Ice and Iceberg Scouring Mechanisms and Properties of Scoured Soils
Engineering Scour Model
Soil/Structures Interaction
Geotechnical Cyclic Loading Analysis
Integrated Geotechnical/Geophysical/Geological Modelling
MARINE GEOLOGY
Shelf Sediment Studies
Hazard Detection and Sediment Transport Modelling
Site Specific Studies - Canada / International
CO-ASI and Instrumented Seabed Sled Studies
Offshore Mineral Resource Evaluation
Analytical Modelling and Field Assessment of Offshore Mineral Deposits

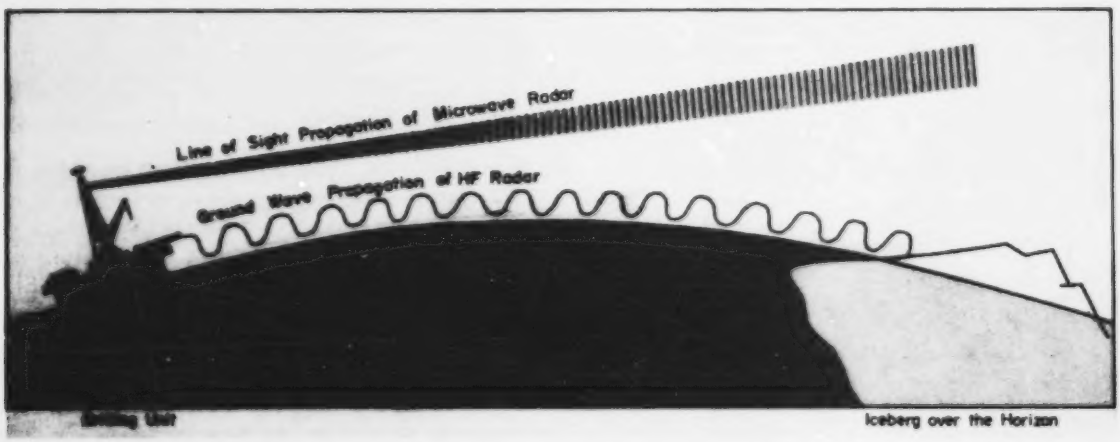
Program reports

Remote Sensing: C-CORE entered into an agreement with NorTek Engineering Ltd. and initiated a commercial venture to undertake phase I of the design of a prototype shore based Ground Wave surveillance radar. This radar will have a long range monitoring capability out to the edge of Canada's territorial limit and provide vessel and iceberg detection. Market surveys indicate that there are commercial applications for these radars in Canada and in other offshore areas. C-CORE has defined the hardware configurations and the Faculty of Engineering's simulation models have been run for various target cross-sections and for several scenarios of system parameters. A Canadian Coast Guard ship assisted in a vessel tracking experiment carried out at Logy Bay. With substantial support from Mobil Oil Canada Ltd., the Remote Sensing Group advanced with the experimental phase of the rig/vessel mounted Ground Wave radar program. This phase will verify the model predictions for the detection of ice targets and solve the engineering problems, such as rig motion and antenna configuration, that are involved in mounting the radar on a rig or vessel. Several experimental options were explored to collect data from an offshore location. Husky/Bow Valley East Coast provided C-CORE with the opportunity to conduct the experiment from the Bow Drill III. The rig operators also provided C-CORE with motion records from the rig to incorporate with the model simulations for ice and ocean returns.

Work between C-CORE and Engineering continued on the ocean wave measurement program funded by an NSERC Strategic Grant. Preliminary results of the radar wave measurements made during the Canadian Atlantic Storms Program (CASP) agreed well with measurements made by more traditional methods.

Testing antenna equipment during an HF radar experiment at Cappahayden.

The Atlantic Oceanographic Laboratory (Fisheries and Oceans Canada) awarded C-CORE a contract to develop a least squares regression method to extract radial current vectors from the radar return. The Centre also explored broader applications for the current measurement techniques using CODAR (Coastal Ocean Dynamics Applications Radar) with the private sector which included search and rescue applications.



Over the horizon detection with Ground Wave radar.

Ice Dynamics: The major program within the Ice Dynamics area was the analysis of the full scale data collected on three iceberg/seabed interactions during the Dynamics of Iceberg Grounding and Scouring Experiment (DIGS). This work was closely linked with the analysis of field data on wave-induced iceberg motion also collected during the DIGS experiment. The data are being analysed in conjunction with experimental and theoretical data. Members of the group also worked closely with Husky/Bow Valley in the evaluation of two search radars employed for operational iceberg detection.

Ice Mechanics: A fundamental research program to study the tridimensional state and failure of ice was initiated with support from NSERC. The first phase of the program studied the effects of multiaxial stress states on ice strength and deformation. A field program was undertaken jointly with the Institute for Marine Dynamics at Resolute Bay, NWT. Field data were collected on the indentation of ice. The Polar Continental Shelf Project provided logistic support. Dr. Flemming Christensen from the Institute of Hydrodynamics and Hydraulic Engineering of the Technical University of Denmark was also involved in the field program at Resolute and in the subsequent data analysis in St. John's.

The Ice Mechanics Group also worked closely on a laboratory based program with the Institute for Marine Dynamics. A number of tasks were undertaken; the main objective, however, was to review multiaxial testing equipment to assist the Institute in the design of its testing equipment.

Another collaborative program was undertaken by researchers at Memorial University, C-CORE, Esso Resources Canada Ltd. and the National Research Council Canada. The field program was carried out on the Kaubvik Caisson Retained Island and monitored the ice loads on the caissons and the foundation response.

Recovering the Wave Induced Ice Motion Package during the LIMEX cruise on the *CSS Baffin*

Labrador Ice Margin Experiment (LIMEX): C-CORE was actively involved in the planning and execution of a major field program which took place at the ice edge on the Grand Banks of Newfoundland. The program was divided into two distinct activities, remote sensing, and ice and oceanography. Many agencies and institutions participated in the field program. International groups included the Scott Polar Research Institute, the Alfred-Wegener Polar Research Institute, Johns Hopkins University and the Naval Ocean Research Development Activity. The C-CORE involvement in LIMEX was supported in a number of ways: Fisheries and Oceans Canada, Physical and Chemical Sciences Branch awarded a contract to MacLaren Plansearch which sub-contracted to C-CORE; Mobil Oil Canada Ltd. seconded an engineer to C-CORE to assist in the logistics during the program; and NSERC provided support under a University Industry Co-operative R&D project. The C-CORE program had three tasks: to measure ice motions induced by wave penetration into the ice field; to measure the strength and conditions of the ice in the marginal ice zone; and to conduct helicopter aerial photography of the ice for further analyses. Good data sets were collected and are now being analysed.

Canadian Sea Ice Information System (CSIIS): The Centre undertook a marketing venture to make the scientific and engineering communities more aware of the capabilities of the database. This venture was funded under the Canada/Newfoundland Ocean Subsidiary agreement. The activities included participation in exhibitions and demonstrations to groups.

Left: Measuring temperature in a core extracted from first-year sea ice on the Beaufort Sea

CO-ASI field trials - Conception Bay, Newfoundland

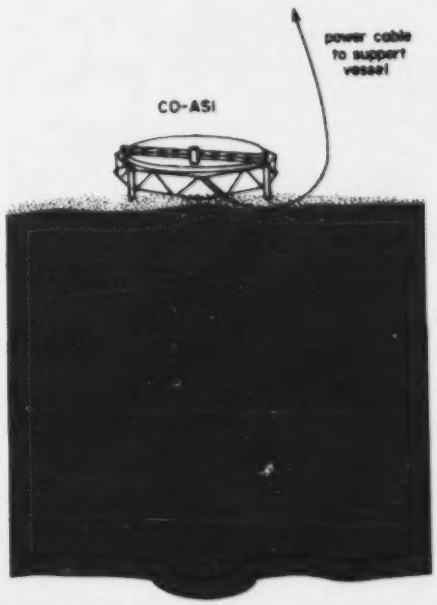
Seabed Geotechnics: A laboratory program funded by the Panel on Energy, Research and Development (PERD) correlated acoustic, physical and behavioural properties of sediments. This investigation represents an on-going investigation of soil properties comprehension; shear wave propagation in silica sands is studied as void ratio is varied.

The Conventional Optimization Acoustic Subseabed Interrogator (CO-ASI) program's objective is to develop a cost effective seabed site survey technique using acoustics. The CO-ASI consists of an advanced multi-tip sparker source and sound intensity directional receivers mounted on a 5m diameter platform. It is being designed to perform layer by layer interrogation of the seabed. Tests in the Institute for Marine Dynamics Seakeeping Tanks were very successful. The system is now under development for testing in the offshore.

The Shelf Sediment Studies project is assessing the geological and geotechnical implications of sediments and structures in the Strait of Belle Isle. Support for this project is being provided by Newfoundland and Labrador Hydro. The data being studied cover 20 years of investigations.

A soil-structure interaction laboratory study is being conducted to assess and monitor the behaviour of a model-scale seabed-founded structure subjected to intense wave loading. Dynamic soil properties are being determined for elastic analysis of the soil-structure interaction. Studies also include the post grounding behaviour of icebergs subjected to intense wave loading. Funds are provided by NSERC for this project.

Advancements in the fundamental principles of acoustics are being applied to the behaviour of energy flow in structures. The program objective is to develop a technique for the remote non-destructive assessment of fatigue and crack growth in offshore structures using acoustic intensity scanning.



Conceptual representation of the CO-ASI taking an acoustic core of the sub-seabed

Associates of C-CORE

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Energy, Mines and Resources Canada
Fisheries and Oceans Canada
National Research Council Canada
Transport Canada

Oil and Gas Industry

Bow Valley Industries Ltd.
Canterra Energy Ltd.
Esso Resources Canada Limited
Gulf Canada Corporation
Husky Oil Operations Ltd.
Mobil Oil Canada Ltd.
Norcen Energy Resources Inc.
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Mr. L. Scott Parsons
Assistant Deputy Minister, Science
Fisheries and Oceans Canada

Dr. Ross Pottie
Executive Vice-President
National Research Council Canada

Mr. W. Thistle
Vice-President (Administration and Finance)
and Legal Counsel
Memorial University of Newfoundland

DEPARTMENT OF THE AUDITOR GENERAL
St. John's, Newfoundland

AUDITOR'S REPORT

The Board of Regents
Memorial University of Newfoundland
St. John's, Newfoundland

I have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at 31 March 1987 and the statements of revenue, expenditure and surplus (deficit) and changes in financial position for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Centre as at 31 March 1987 and the results of its operations and the changes in financial position for the year then ended in accordance with the accounting principles described in Note 1 to the financial statements applied on a basis consistent with that of the preceding year.

J.F. McGrath, C.A.
Auditor General

St. John's, Newfoundland
22 September 1987

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
STATEMENT 1: BALANCE SHEET AS AT 31 MARCH 1987

		1987		1986
ASSETS				
Current assets:				
Research trust (Note 3)		$ 956,484		$ 939,020
Accounts receivable				
Operating		393,695		102,530
Total current assets		1,350,179		1,041,550
Fixed assets - at cost				
Bartlett Building (Note 4)		1,038,841		1,038,841
Equipment (Note 5)	$1,396,317		$1,249,753	
Less: Accumulated depreciation	1,013,379	382,938	834,435	415,318
Total fixed assets		1,421,779		1,454,159
Total assets		$2,771,958		$2,495,709

	1987	1986
LIABILITIES AND EQUITY		
Current liabilities:		
Accounts payable and accrued liabilities		
Operating	$ 58,994	$ 30,377
Current portion of deferred revenue (Note 8)	76,667	76,667
Interest-free advance from Memorial University of Newfoundland	338,424	52,170
Total current liabilities	474,085	159,214
Long-term liabilities		
Interest-free demand loan from Memorial University of Newfoundland (Note 7)	230,598	265,598
Deferred revenue (Note 8)	76,668	153,335
Total long-term liabilities	307,266	418,933
Total liabilities	781,351	578,147
Equity		
Equity in research trust	956,484	939,020
Equity in building	1,038,841	1,038,841
(Deficit)	(4,718)	(60,299)
Total equity	1,990,607	1,917,562
Total liabilities and equity	$2,771,958	$2,495,709

See accompanying notes

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
STATEMENT 2: REVENUE, EXPENDITURE AND SURPLUS (DEFICIT)
FOR THE YEAR ENDED 31 MARCH 1987

	1987	1986
REVENUE		
Research trust drawdowns	$ 600,000	$ 948,000
Research contracts	986,421	767,854
Other	26,123	18,214
Total revenue	1,612,544	1,734,068
EXPENDITURE		
Board of Governors	6,722	19,513
Fellowships and training	42,378	75,781
Ocean Engineering Information Centre	137,562	76,989
Research programs	374,235	388,196
Staff salaries	914,225	1,157,458
Support services	81,841	123,493
Total expenditure	1,556,963	1,841,430
Excess of revenue over expenditure (expenditure over revenue)	55,581	(107,362)
Surplus (deficit) - beginning of year	(60,299)	47,063
(Deficit) - end of year	$ (4,718)	$ (60,299)

See accompanying notes

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
STATEMENT 3: CHANGES IN FINANCIAL POSITION
FOR THE YEAR ENDED 31 MARCH 1987

	1987	1986
Cash provided by (used in) operating activities		
Industry	$ 447,500	$ 434,700
Government	105,648	119,560
Investments	64,316	89,613
	617,464	643,873
Transferred to operations	(600,000)	(948,000)
Increase (decrease) in cash during the year	17,464	(304,127)
Cash, beginning of year	939,020	1,243,147
Cash, end of year (Note 9)	$ 956,484	$ 939,020

See accompanying notes

Signed on behalf of Memorial University of Newfoundland

Chairman of the Board of Governors

Comptroller of Memorial University of Newfoundland

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
NOTES TO FINANCIAL STATEMENTS
FOR THE YEAR ENDED 31 MARCH 1987

1. **Accounting policies**

(a) Basis of accounting

C-CORE follows the accrual basis of accounting except that contributions to C-CORE's research programs are deposited for credit to the C-CORE Research Trust, which is shown on a cash basis (Note 3).

(b) Depreciation

Depreciation is not recorded on the Bartlett Building (Note 4), however depreciation on other fixed assets is calculated on a straight line basis as follows:

Equipment	5 years
Tools and marine equipment	2 years
Computer software and other equipment	1 year

(c) Support-in-kind

Various services have been provided to C-CORE by Memorial University of Newfoundland and other agencies, without charge, and have not been included in these financial statements (Note 6).

2. **Relation to Memorial University of Newfoundland**

The Centre for Cold Ocean Resources Engineering (C-CORE) is a self-reliant organization of Memorial University which is owner of C-CORE's building and equipment and beneficiary of its assets and liabilities. In the event that C-CORE is terminated, facilities and equipment provided or acquired for C-CORE shall remain the absolute property of the University.

As such, these financial statement figures represent a segment of the activities of Memorial University of Newfoundland and are included in the audited financial statements of the University for the year ended 31 March 1987.

3. **Funds in Research Trust**

The Comptroller of Memorial University of Newfoundland administers the C-CORE Research Trust on behalf of the Trustee, the Board of Regents of Memorial University.

4. **Bartlett Building**

In order to properly reflect the entire operations of C-CORE as a separate entity, the Bartlett Building, which is owned by Memorial University of Newfoundland but of which C-CORE has exclusive use, has been included in the financial statements at a cost of $1,038,841.

5. **Equipment**

C-CORE accounts for its equipment in three main categories, as outlined in Note 1.

Category	Acquisitions Less Disposals Since Inception	Accumulated Depreciation	Net Book Value 1987	Net Book Value 1986
Equipment	$1,282,474	$ 899,536	$382,938	$414,237
Tools and marine equipment	91,941	91,941	-	1,081
Computer software and other equipment	21,902	21,902	-	-
	$1,396,317	$1,013,379	$382,938	$415,318

C-CORE's equipment includes a VAX 785 computer and accessories. The Province of Newfoundland contributed $191,668 towards the cost of this computer and they have secured their contribution by way of a chattel mortgage dated 23 May 1985, which is being forgiven by the Province at a rate of 25% per year.

The Government of Canada also contributed $191,668 towards the cost of this computer. Terms of this contracted contribution require C-CORE to provide for the implementation and provision of a Sea Ice Data Base Service over the period from 22 January 1985 to 31 March 1989.

6. **Support-in-kind**

Management has estimated the cost of various services provided without charge by Memorial University of Newfoundland and other agencies at $668,700 for the year ended 31 March 1987 ($2,270,100 - 1986). This figure is a representation by management and it has not been audited.

7. **Interest-free demand loan**

The interest-free demand loan of $230,598 ($265,598 - 1986) represents the cumulative difference to 31 March 1985 between revenues and expenditures that have been advanced by Memorial University of Newfoundland to C-CORE. This amount was fixed by an agreement between Memorial University of Newfoundland and C-CORE dated 12 February 1987 which is effective from 31 March 1986.

8. **Deferred revenue**

Government contributions of $383,336 have been recorded as deferred revenue to be amortized to revenue over a five year period on a straight line basis. Of this amount, $76,667 has been included in revenue for the year ended 31 March 1987.

9. **Change in financial statement presentation**

During the year C-CORE changed its definition of funds from working capital to cash resources. The 1985-86 comparative figures for the statement of changes in financial position have been restated to reflect this change.
Cash has been defined as resources deposited in the Research Trust Fund.

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86-B Josenhans, H.W., Barrie, J.V., Woodworth-Lynas, C.M.T. and Parrott, D.R. "DIGS '85: Dynamics of Iceberg Grounding and Scouring: Observations of Iceberg Scour Marks by Manned Submersible". Abstract, 14th Arctic Workshop: Arctic Land-Sea Interaction, Bedford Institute of Oceanography, Dartmouth, N.S., Nov. 6-8, 1985, p. 92.

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87-B C-CORE News, Vol. 12, Nos. 1 and 2, June 1987, 12 p.

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The Centre for Cold Ocean Resources Engineering (C-CORE) is an independently funded research centre in St. John's located at Memorial University of Newfoundland. The Centre's mandate is to undertake research that will assist the safe and orderly development of Canada's resources in cold and ice frequented oceans.

Initially, C-CORE's funding was provided by the Devonian Group of Charitable Foundations of Calgary. Ongoing funding now comes from government and industry.

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